Canadian Centre for Occupational Health and Safety

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Dust and its Effect on the Lungs

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DUST AND ITS EFFECT ON THE LUNGS

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INTRODUCTION

The classic diseases of "dusty" occupations may be on the decline, but they have not yet disappeared. Workers today still suffer from a variety of illnesses caused by dust they inhale in their work environments. For practical purposes, we limit this document to dust. We do not take into consideration combined effects arising from exposures to dusts, gases, fumes and vapours.

1. THE LUNGS

The lungs are the organs of breathing that communicate with the atmosphere through a series of branching air tubes (see diagram below). The lungs are constantly exposed to the danger posed by the dust we breathe. But they are protected by defense mechanisms. For example, during a lifetime, a coal miner may receive 1,000g of dust in his lungs. When doctors examine the lungs of a miner after death, they find no more than 40g of dust. So little residue illustrates the importance of the lungs' defenses, and certainly suggests that they are quite effective.

On the other hand, despite the capacity of the lungs to clear themselves, excessive inhalation of dust may result in disease.

1. bones and cartilage in the nose that makes inhaled air swirl to deposit large particles
2. mouth - has no filtering system
3. tongue
4. pharynx
5. esophagus - tube leading to the stomach
6. opening of trachea
7. trachea - tube leading to the lungs
8. bronchus
9. bronchiole
10. tiny air sacs (alveoli) at the end of each bronchial "tree" branch

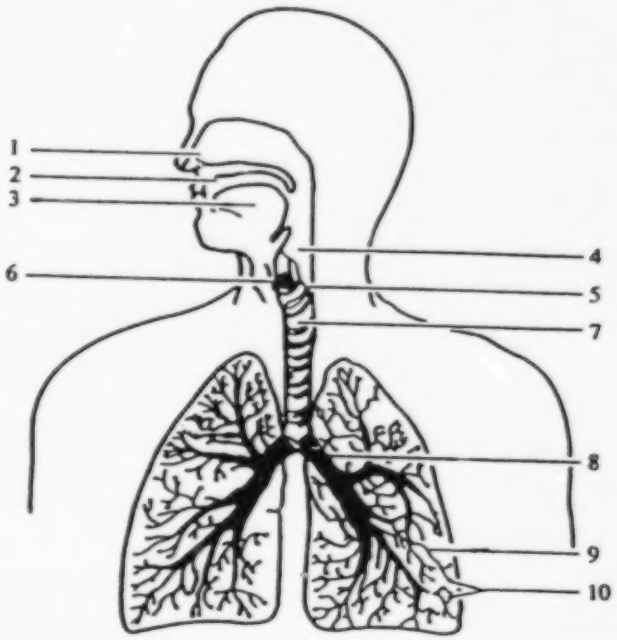

Diagram of airway passage to the lungs showing the routes taken by contaminated air

The lungs are protected by a series of defense mechanisms in different regions of the respiratory tract.

When a person breathes in, particles suspended in the air enter the nose, but not all of them reach the lungs. The nose is an efficient filter. Most large particles are stopped in it, until they are removed mechanically by blowing the nose or sneezing. Some of the smaller particles succeed in passing through the nose to reach the windpipe and the dividing air tubes that lead to the lungs. These tubes are called bronchi and bronchioles. All of these airways are lined by cells. The mucus they produce catches most of the dust particles. Tiny hairs called cilia, covering the walls of the air tubes, carry the mucus upward and out into the throat, where it is either coughed up and spat out, or swallowed.

The air reaches the tiny air sacs in the inner part of the lungs with any dust particles that avoided the defenses offered by the nose and airways. The air sacs are very important because through them, the body receives oxygen and releases carbon dioxide.

Dust that reaches the sacs and the lower part of the airways where there are no cilia is attacked by special cells called macrophages. These are extremely important for the defense of the lungs. They keep the air sacs clean. Macrophages virtually swallow the particles. Then the macrophages, in a way which is not well understood, reach the part of the airways that is covered by cilia. The wave-like motions of the cilia move the macrophages which contain dust to the throat, where they are spat out or swallowed.

Besides macrophages, the lungs have another system for the removal of dust. The lungs can react to the presence of germ-bearing particles by producing certain proteins. These proteins attach to particles to neutralize them.

2. DUSTS

Dusts are tiny solid particles scattered in the air. The particles are "inorganic" or "organic," depending on the source of the dust. Inorganic dusts come from minerals such as rock or soil. Examples of inorganic dusts are silica, asbestos, and coal.

Organic dusts originate from plants or animals. These dusts contain a great number of substances.

Aside from the vegetable or animal component, they may also contain microbes and the toxic substances given off by microbes. An example of organic dust is that which arises from handling grain.

3. REACTIONS OF THE LUNGS TO DUST

The way the respiratory system responds to inhaled particles depends, to a great extent, on where the particle settles. For example, irritant dust that settles in the nose may lead to rhinitis, an inflammation of the mucous membrane. If the particle attacks the larger air passages, inflammation of the trachea (tracheitis) or the bronchi (bronchitis) may be seen.

The most significant reactions of the lung occur in the deepest parts of this organ.

Particles that evade elimination in the nose or throat tend to settle in the sacs or close to the end of the airways. But if the amount of dust is large, the macrophage system may fail. Dust particles and dust-containing macrophages collect in the lung tissues, causing injury to the lungs.

The amount of dust and the kinds of particles involved influence how serious the lung injury will be. For example, after the macrophages swallow silica particles, they die and give off toxic substances. These substances cause fibrous or scar tissue to form. This tissue is the body's normal way of repairing itself. But with silica it gets out of hand. Too much fibrous tissue is formed in the lungs, a condition called fibrosis. The particles which cause fibrosis or scarring are called fibrogenic.

4. FACTORS INFLUENCING THE EFFECTS OF DUST

Several factors influence the effects of inhaled particles. Among these are some properties of the particles themselves. Size and heaviness are important because large and heavy particles settle more rapidly. Chemical composition is important because some substances, when in particle form, can destroy the cilia that the lungs use for the removal of particles. Cigarette smoking may alter the ability of the lungs to clear themselves.

Characteristics of the person inhaling particles can also influence the effects of dust. Breathing rates and smoking are among the most important. The settling of dust in the lungs increases with the length of time the breath is held and how deeply the breath is taken. Whether breathing is through the nose or mouth is also important.

5. DISEASES OF DUSTY OPERATIONS

Some types of lung diseases caused by the inhalation of dust are called by the general term "pneumoconiosis." This simply means "dusty lung."

The changes which occur in the lungs vary with the different types of dust. For example, the injury caused by exposure to silica is marked by islands of scar tissue surrounded by normal lung tissue. Because the injured areas are separated from each other by normal tissue, the lungs do

not completely lose their elasticity. In contrast, the scar tissue produced following exposure to asbestos, beryllium and cobalt completely covers the surfaces of the deep airways. The lungs become stiff and lose their elasticity.

Not all inhaled particles produce scar tissue. Dusts such as carbon and iron remain within macrophages until they die normally. The released particles are then taken in again by other macrophages. If the amount of dust overwhelms the macrophages, dust particles coat the inner walls of the airways without causing scarring, but only producing mild damage, or may be none at all.

Some particles dissolve in the bloodstream. The blood then carries the substance around the body where it may affect the brain, kidneys and other organs.

The following table summarizes some of the most common lung diseases caused by dust.

Table - Some types of pneumoconiosis according to dust and lung reaction

Inorganic Dust	Type of Disease	Lung Reaction
Asbestos	Asbestosis	Fibrosis
Silica (Quartz)	Silicosis	Fibrosis
Coal	Coal Pneumoconiosis	Fibrosis
Beryllium	Beryllium Disease	Fibrosis
Tungsten Carbide	Hard Metal Disease	Fibrosis
Iron	Siderosis	No Fibrosis
Tin	Stannosis	No Fibrosis
Barium	Baritosis	No Fibrosis

Organic Dust	Type of Disease	Lung Reaction
Mouldy Hay, Straw and Grain	Farmer's Lung	Fibrosis
Droppings and Feathers	Bird Fancier's Lung	Fibrosis
Mouldy Sugar Cane	Bagassosis	Fibrosis
Compost Dust	Mushroom Worker's Lung	No Fibrosis
Dust or Mist	Humidifier Fever	No Fibrosis
Dust of Heat-Treated Sludge	Sewage Sludge Disease	No Fibrosis
Mould Dust	Cheese Washers' Lung	No Fibrosis
Dust of Dander, Hair Particles and Dried Urine of Rats	Animal Handlers' Lung	No Fibrosis

6. DUST PROTECTION

To avoid respiratory or other problems caused by exposure to dust, hazardous substances should be substituted with non-hazardous substances. Where substitution is not possible, other engineering control methods should be introduced. These include:

- use of wet processes
- enclosure of dust-producing processes under negative air pressure (vacuum)
- exhausting air containing dust through a collection system before emission to the atmosphere
- use of vacuums instead of brooms
- good housekeeping
- efficient storage and transport
- controlled disposal of dangerous waste

Use of personal protective equipment may be vital, but it should nevertheless be the last resort of protection. Personal protective equipment should not be a substitute for proper dust control and should be used only where dust control methods are not yet effective or are inadequate.

Workers themselves, through education, must understand the need to avoid the risks of dust.

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